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Seed yield and yield attributes of onions as influenced by surface cutting, weight, and planting date of mother bulbs

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ABSTRACT

Purpose: This investigation aimed to study the effect of mother bulb surface cutting, weight and date of planting on plant growth, seed yield and seed quality of onions. **Research method:** The experiment was conducted during 2020 at the Agriculture Research Farm of Kabul University. The study was designed in split-split plot Randomized Complete Block Design (RCBD) and data for plant biometry, seed yield and seed quality was recorded. The recorded data were statistically analyzed with R software. **Findings:** The study revealed that, surface cutting of mother bulbs alone does not influence plant growth and seed yield. However, the interaction of large bulb and bulb surface cutting was significant on seed yield. The large sized whole bulbs produced higher seed yield (938.33 Kg ha^{-1}) as compared to other treatments. Early planting produced vigorous plants as compare late planting. Large bulbs (126-175 g) produced vigorous plants and highest seed yield (820.83 Kg ha^{-1}). However, the seed yield (805.83 Kg ha^{-1}) produced by plants obtained from medium bulbs (76-125 g) was on par with those produced from large bulbs. **Research limitations:** No limitations to report. **Originality/Value:** Based on the findings of the study, the farmers are recommended to avoid the surface cutting of mother bulbs and follow early planting (20th March) of medium sized bulbs (76-125 g) for vigorous plants and higher seed yield of onion.

INTRODUCTION

Onion (*Allium cepa* L.) is one the largest commercial vegetables in the world, belonging to the *Alliaceae* family. It is a biennial herbaceous plant (Tungland, 2018), which is grown as an annual plant for production of bulbs and biennial for production of seed (Gupta et al., 2003). Access to high quality seed is continuous demand of farmers but due to its highly cross-pollinating nature the production of genetically pure and high-quality onion seed is difficult at local farmers' level.

Cultivar, crop physiology, vernalization, size of mother bulb, environment and cultural practices influences the quality of onion seed. Khokhar (2009) revealed that, genotype, location, growing season, and method of seed production influences the quality of onion seed.

The surface cutting of mother bulb is a common practice among farmers which do not have significant influence on plant growth and seed yield and may increase the chance of pest and disease infection (Simon et al., 2015; Woldeselassie, 2014). However, the cut bulbs treated with fungicide can significantly increase the plant growth and seed yield of onion.

Early planting of onion mother bulbs results in vigorous plant growth and higher seed yield and quality. It can also reduce the risk of adverse climatic conditions such as early showers and rapid temperature increase (Ashagrie et al., 2014; Mehri et al., 2015; Mishra et al., 2002; Mollah et al., 2015; Rafieipour et al., 2011; Tesfaye et al., 2018).

Ali et al., (1998) stated that, food supply and water resources are higher in large bulbs which allows them to develop vigorous and high seed yielding plants. The plants obtained from large sized mother bulbs produces vigorous plants with higher number of leaves, leaf length, leaf area, flower stalks, capsules per umbel, seeds per capsule and umbels per plant (Hussain et al., 2001; Khodadadi, 2012; Khokhar, 2009; Reghin et al., 2005). The studies also revealed that, the plants obtained from large bulbs produced higher seed yield as compare to those obtained from small bulbs (Ashagrie et al., 2014; Khokhar, 2009; Manna, 2016; Mosleh UD Deen, 2008).

Surface cutting of mother bulb and late planting are common practices followed by conventional farmers in Afghanistan. Such practices increase the risk for crop to be affected by adverse climate, pests, and diseases. The farmers also use large sized mother bulbs for seed production of onion crops, which causes economic losses due to higher rate of storage decay and wastage of fresh produce.

The objective of present investigation was to study the effect of surface cutting, weight, and date of planting of mother bulbs on plant growth, seed yield and seed quality of onions.

MATERIALS AND METHODS

The study was conducted in the research farm of Agriculture faculty of Kabul University during the months of March to December 2020. The site of the investigation is located at latitude 34.5184 °N and longitude 69.1394 °E. The elevation of site is 1810 meters above mean sea level (Safi et al., 2016). The climate of the region is dry temperate with hot summer and cold winter (Salari et al., 2020). The growing season in the region starts in April and extends up to November. The average weather data of year 2020 for the experiment site is presented in Table 1.

Table 1. Average weather data of the experiment site during 2020 (POWER Data Access Viewer, 2021) and *(Sunrise and Sunset in Afghanistan, 2021).

Month	Maximum Temperature (^{0}C)	Minimum Temperature (^{0}C)	Relative Humidity (%)	Day length (hours)*	Rainfall (mm)
January	0.09	-10.38	66.30	10.1	41.57
February	7.16	-4.84	56.83	11.0	44.86
March	8.12	-2.72	69.83	11.6	187.01
April	14.59	2.24	66.76	13.1	179.16
May	19.45	5.50	59.14	14.0	48.53
June	25.59	9.01	37.46	14.3	7.63
July	28.03	11.64	32.55	14.2	6.83
August	29.70	12.34	30.28	13.3	5.83
September	24.78	7.24	24.51	12.3	15.16
October	16.88	0.63	33.31	11.2	52.97
November	9.90	-2.93	46.33	10.3	51.59
December	4.73	-6.57	56.50	9.5	29.85

The investigation was conducted in Split-Split Plot Randomized Complete Block Design (RCBD) with twelve treatments each replicated three times. The mother bulb surface cutting at two levels (cut and whole) were applied randomly in the main plots. The date of planting at two levels (20th March and 5th April) was allotted randomly in sub plots. The weight of mother bulb at three levels (26-75 g, 76-125 g and 126-175 g) was allotted randomly in sub-sub plots.

The local onion variety named *Safid e Paisaye* was used in this investigation. The recommended dose of nitrogen (90 kg ha^{-1}), phosphorus (60 kg ha^{-1}), potassium (45 kg ha^{-1}), and farmyard manure (15 t ha^{-1}) were applied in common to all the plots. Based on climatic conditions, the plots were irrigated once in each 7-10 days using common flood irrigation method. The bulbs were planted with rows spaced 0.4 m apart and an in-row plant distance of 0.3 m. The weeds were controlled manually by hand weeding (Salari et al., 2021). The plants were sprayed with 0.2 % Mancozeb fungicide solution to prevent fungal diseases such as powdery mildew. The umbels were manually harvested when the capsules started partial opening, they were then dried under shade in well-ventilated place. The seeds were manually threshed with human labor. The seeds were further dried under shade till 6 to 7% moisture level was attained (Hakimi et al., 2017).

The parameters on plant growth were recorded at 60 days after planting of mother bulbs. The numbers of leaves per plant were manually counted in selected three plants from each treatment. The leaf length was measured in centimeters from the base to tip of the leaf. Using the millimeter graph paper method given by (Pandey & Singh, 2011), the leaf area per plant was recorded from three randomly labeled plants in each treatment and was presented as square centimeter per plant. Leaf area index (LAI) was calculated by dividing the actual leaf area per plant by land area occupied by the same plant using the formula (1) given by (Watson, 1952).

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area occupied by each plant (cm}^2\text{)}} \quad (1)$$

The flower stalks per plant were manually counted in selected three plants in each treatment. The flower stalk length was measured in centimeters from the base to tip of the stalk at the time of harvest. The seed yield of each treatment was recorded in grams per plot and presented in kilograms per hectare. One hundred seeds from each treatment were manually counted and weighed using high precision mg scale (0.001 g) (UW220H Precision Scale from Shimadzu, 2021).

For seed germination test, one hundred seeds from each treatment were placed on absorbent paper in petri dish and were sprayed with distilled water. Optimum environmental conditions such as temperature (20 °C), relative humidity (above 90 percent) and light (12 hours) were ensured for the period (Hakimi, 2019). The number of seeds germinated within two weeks was manually counted and were presented as percent germination.

The R studio software was used for analysis of obtained data. The differences between treatments were compared using Least Significant Difference (LSD) at $p \leq 0.05$.

RESULTS AND DISCUSSION

Number of leaves per plant

The effects of mother bulb weight were highly significant on number of leaves per plant. The highest number of leaves (28.97) was recorded for the plants obtained from largest bulbs (126-175 g) and the lowest (20.67) were recorded for the plants obtained from the smallest bulbs (26-75 g) (Table 2).

The effect of interaction between mother bulb surface cutting and date of planting was significant on number of leaves per plant. The highest number of leave per plant (31.89) was recorded under the combination of whole mother bulb and largest sized bulbs and the lowest (19.78) were recorded under the combination of whole bulb and smallest sized bulbs (Fig. 1).

The effect of interaction between surface cutting, weight, and planting date of mother bulbs was also significant on number of leaves per plant. The highest number of leaves (32.66) was produced by the plants obtained under the combination of whole mother bulb, early planting date (20th March) and large mother bulbs (126-175 g). The plants obtained under the combination of whole mother bulb, late planting date (5th April) and small sized bulbs (26-75 g) produced the lowest number of leaves per plant (19.00) (Fig. 2).

The large bulbs planted in early planting date (20th March) produced higher number of leaves per plant as compared to other treatments. This might be due to exposure of plants to relatively cooler period which stimulates cytokine and gibberellin accumulation and leads to increase plant development (Tesfaye et al., 2018). The availability of higher food resources in large bulbs may also be associated with the higher number of leaves per plant. The results are in agreement with the findings of (Amalfitano et al., 2019; Manna, 2016). They reported that, large bulbs have higher food supply and water resources to produce vigorous plants.

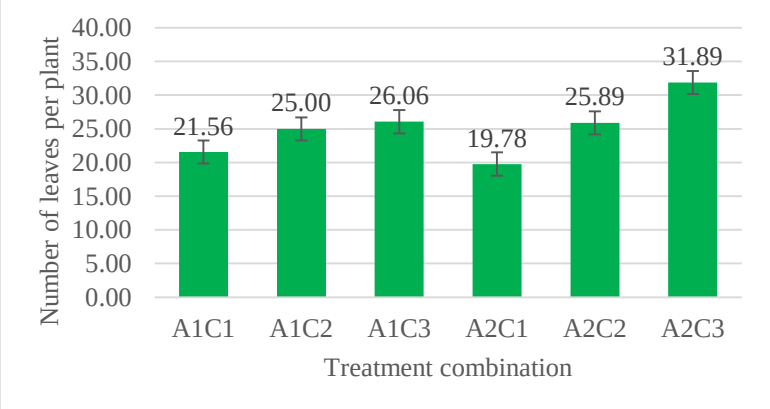

Fig. 1. The number of leaves per plant of onion as affected by interaction among mother bulb surface cutting (A1: Cut bulbs, A2: Whole bulbs) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

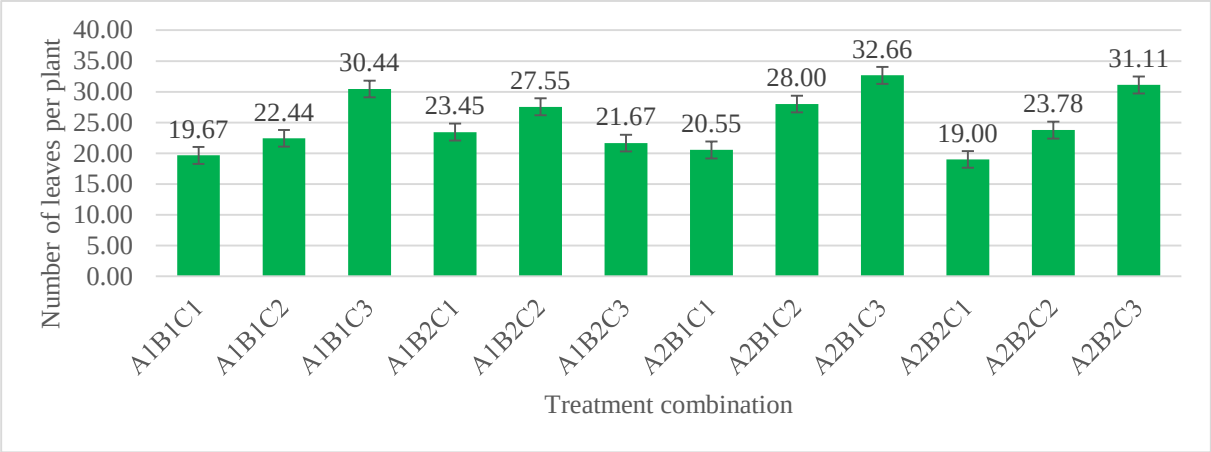

Fig. 2. The number of leaves per plant of onion as affected by interaction among mother bulb surface cutting (A1: Cut bulbs, A2: Whole bulbs), date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

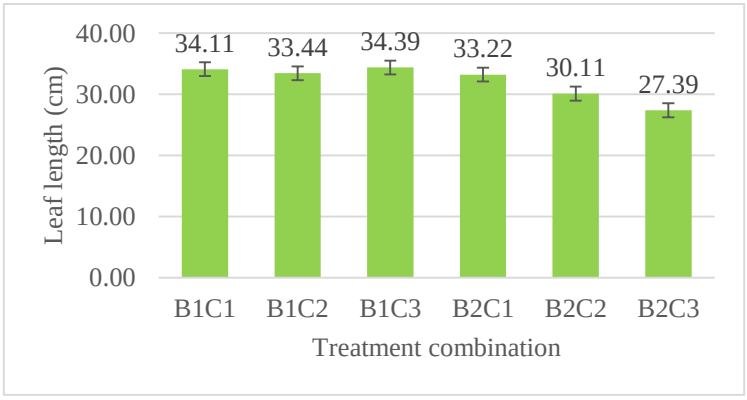

Fig. 3. The leaf length of onion as affected by interaction among date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

Leaf length

The date of planting had significant effect on leaf length. The longest leaves (33.98 cm) were observed under the early plating date (20th March) and the shortest leaves (30.24 cm) were recorded under the late planting date (5th April) (Table 2).

The effect of interaction between planting date and mother bulb was significant on leaf length. The highest length of leaves (34.39 cm) was recorded under the combination of early planting date (20th March) and large sized bulbs (126-175 g). The combination of late planting date (5th April) and large sized bulbs (126-175 g) recorded the lowest leaf length (27.39 cm) (Fig. 3).

The plants obtained from early planted large bulbs were taller as compared to the plants obtained from late planted small bulbs. The balance of plant hormones caused by relatively cooler weather conditions in combination with the increased food and water resources in large bulbs might be associated with the increased leaf length. The results are in line with the findings of (Aboukhadrah et al., 2017; Ali et al., 2016; Tesfaye et al., 2018).

Leaf area per plant

The date of planting had significant effect on leaf area per plant of onions. The highest leaf area per plant (1538.03 cm^2) was recorded under the early planting date (20th March) and the lowest (1111.29 cm^2) was recorded under the late planting date (5th April) (Table 2). The

effect of mother bulb weight was also significant on leaf area per plant. The highest leaf area (1569.53 cm^2) was recorded for the plants produced from large bulbs and the lowest (1142.67 cm^2) was recorded for the plants produced from small bulbs (Table 2).

The interaction between planting date and bulb weight recorded significant effect on leaf area per plant. The highest leaf area (2032.32 cm^2) was recorded under the combination of early planting date (20th March) and large bulbs (126-175 g). The combination of late planting date (5th April) and small bulbs recorded the lowest leaf area per plant (1097.80 cm^2) (Fig. 4).

The highest leaf area per plant was recorded for the plants obtained from early planted large bulbs. The leaf area per plant is correlated with the number of leaves per plant and leaf length. Since the taller plants having higher number of leaves were produced under early planted large bulbs thereby, this is obvious that same combination of the treatments would record higher leaf area per plant as well. The results are in agreement with the findings of (Amalfitano et al., 2019; Khokhar, 2009; Mosleh UD Deen, 2008; Tesfaye et al., 2018).

Leaf area index

The effect of planting date and weight of mother bulb was significant on leaf area index of onions. The highest leaf area index (1.28) was recorded under the early planting date (20th March) and the lowest (0.93) was recorded under the late planting date (5th April). Similarly, the highest leaf area index (1.31) was recorded under the large bulbs (126-175 g) and the lowest (0.95) was recorded under the small bulbs (26-75 g) (Table 2).

The interaction between planting date and weight of mother bulb had significant effect on leaf area index of onions. The combination of early planting date (20th March) and large bulbs (126-175 g) recorded the highest leaf area index (1.69) and the combination of late planting date (5th April) and small bulbs (26-75 g) recorded the lowest leaf area index (0.92) (Fig. 4).

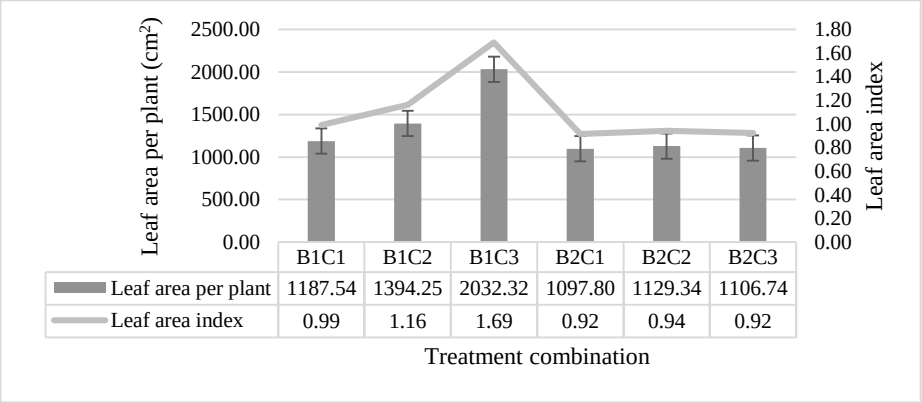

Fig. 4. The leaf area per plant (cm^2) and leaf area index of onion as affected by interaction among date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

Table 2. The growth of onion plants as influenced by surface cutting, weight, and planting date of mother bulb

Treatment	Number of leaves per plant	Leaf length (cm)	Leaf area (cm^2) per plant	Leaf area index
Bulb surface cutting (A):				
Cut	24.20±1.04	31.44±0.94	1248.39±76.18	1.04±0.06
whole	25.85±1.69	32.78±0.87	1400.94±137.82	1.17±0.12
Planting date (B):				
20th March	25.63±1.38	33.98±0.64a	1538.03±124.79a	1.28±0.10a
5th April	24.43±1.44	30.24±0.94b	1111.29±67.47b	0.93±0.06b
Bulb weight (C):				
26-75 g	20.67±0.97c	33.67±0.73	1142.67±63.32b	0.95±0.05b
76-125 g	25.44±1.16b	31.78±0.88	1261.79±74.86b	1.05±0.06b
126-175 g	28.97±1.96a	30.89±1.50	1569.53±201.58a	1.31±0.17a
Bulb surface cutting (A):				
F-test	NS	NS	NS	NS
Planting date (B):				
F-test	NS	*	*	*
$LSD_{0.05}$		3.32	292.50	0.24
CV (%)		11.20	23.90	23.90
Bulb weight (C):				
F-test	**	NS	*	*
$LSD_{0.05}$	3.10		280.80	0.23
CV (%)	13.90		24.50	24.60
Interaction:				
A×B	NS	NS	NS	NS
A×C	*	NS	NS	NS
B×C	NS	*	*	*
A×B×C	*	NS	NS	NS

* and NS stands for significant and non-significant, respectively. Values in the same column for each factor followed by the same letter are not significantly different, according to LSD at 0.05 level. ± SE.

Leaf area index is dependent on leaf area per plant and area occupied by a plant. In this investigation the plants in all treatments occupied the same size of land hence the leaf area index was totally dependent on leaf area per plant. The plants produced from early planted large and medium sized bulbs recorded a leaf area index of higher than one which show the vigorous plant growth and efficient use of land resources. The authors (Amalfitano et al., 2019; Khodadadi, 2012; Tesfaye et al., 2018) also reported that, the plants obtained from early planted large bulbs are vigorous as compare to the plants obtained from late planted small bulbs.

Number of flower stalks per plant

The weight of mother bulb recorded highly significant influence on number of flower stalks per plant. The number of flower stalks increased with increase in bulb weight, the highest number of flower stalks per plant (3.70) was recorded for the large sized bulbs (126-175 g) which was on par with medium sized bulbs. The lowest number of flower stalks per plant (2.95) was recorded for the small sized bulbs (26-75 g) (Table 3).

The effect of interaction of planting date and mother bulb weight was found significant on number of flower stalks per plant. The combination of early planting date (20th March) and large sized bulbs produced the highest number of flowing stalks per plant (3.95) and the combination of early planting (20th March) small sized bulb produced the lowest number of flower stalks per plant (2.56) (Fig. 5).

The interaction of surface cutting, weight, and planting date of mother bulb also had significant effect on number of flower stalks per plant. The highest number of flower stalks (4.22) was observed under the combination of cut mother bulbs, late planting date (5th April) and medium sized mother bulbs (76-125 g) (Fig. 6). The combination of cut mother bulbs, early planting date and small sized bulbs recorded the lowest number of flower stalks per plant (2.56) which was on par with the number of flower stalks produced under the combination of whole mother bulbs, early planting date and small sized mother bulbs (Fig. 6).

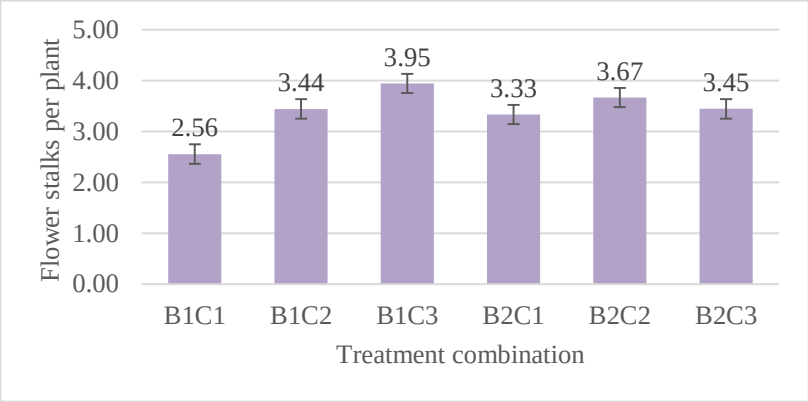

Fig. 5. The number of flower stalks per plant of onion as affected by interaction among date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

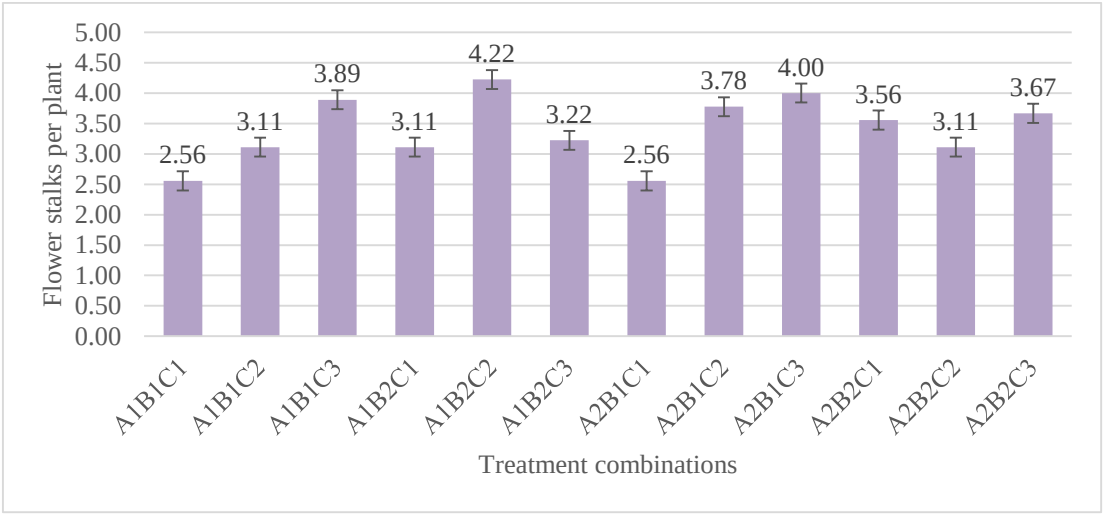

Fig. 6. The number of flower stalks per plant of onion as affected by interaction among mother bulb surface cutting (A1: Cut bulbs, A2: Whole bulbs), date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

The early planted larger bulbs produced higher number of flower stalks per plant. The vigorous growth of plants produced from early planted large bulbs is the possible reason for higher number of flower stalks per plant. (Tesfaye et al., 2018) reported that, accumulation of cytokine and gibberellin stimulated by cold air are responsible for growth of flower stalk. The results are also in line with the findings of (Ashagrie et al., 2014; Mehri et al., 2015; Mollah et al., 2015; Rafieipour et al., 2011; Reghin et al., 2005).

Length of flower stalk

The length of flower stalk was not significantly influence by the factors studied in this investigation. The effect of the interaction of the studied factors was also non-significant on length of flower stalks (Table 3).

Seed yield

The bulb weight had significant effect on seed yield and the larger sized bulbs (126-175 g) produced the highest yield (820.83 Kg ha^{-1}) which was on par with the yield of medium sized bulbs (805.83 Kg ha^{-1}). The lowest yield (699.17 Kg ha^{-1}) was recorded for the small sized bulbs (26-75 g) (Table 3).

The interaction effect of mother bulb surface cutting and weight of mother bulb was found significant on seed yield. The highest yield (938.33 Kg ha^{-1}) was recorded under the combination of large sized whole bulbs and the lowest (690 Kg ha^{-1}) was recorded under the combination of small sized whole bulbs (Fig. 7).

The interaction between planting date and bulb weight had significant effect on seed yield of onion. The highest seed yield (908.33 Kg ha^{-1}) was recorded under the combination of early planting date (20th March) and medium sized bulbs (76-125 g) and the lowest (668.33 Kg ha^{-1}) was recorded under the combination of early planting date (20th March) and small sized bulbs (26-75 g) (Fig. 8).

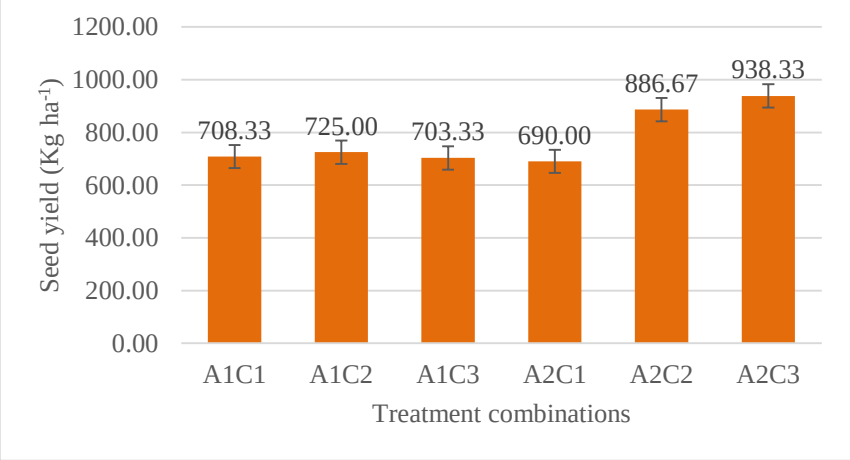

Fig. 7. The seed yield (Kg ha^{-1}) of onion as affected by interaction among mother bulb surface cutting (A1: Cut bulbs, A2: Whole bulbs) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

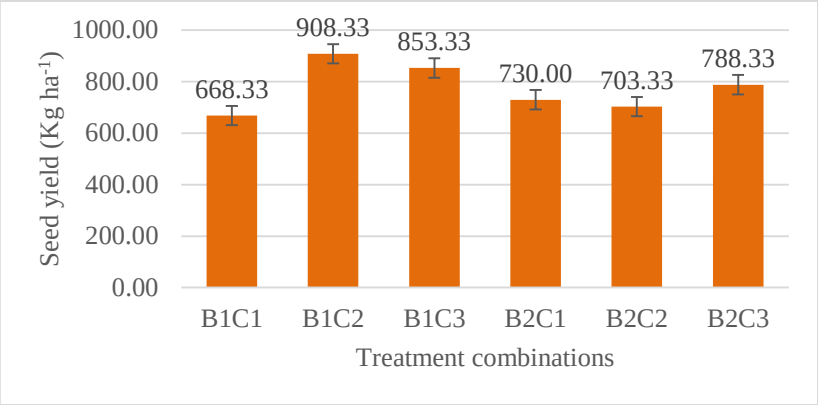

Fig. 8. The seed weight (Kg ha^{-1}) of onion as affected by interaction among date of planting (B1: Planted on 20th March, B2: Planted on 5th April) and mother bulb weight (C1: Bulbs weighed 26-75 g, C2: Bulbs weighed 76-125 g, C3: Bulbs weighed 126-175 g).

The large sized whole bulbs grown in early planting date produced higher seed yield as compared to other treatments. The large bulbs had higher food and water resources to produce stronger plants with vigorous growth and higher number of flowing stalks. In addition, the improved balance of plant hormones caused by cooler temperature under early planting date also promoted the vigorous growth of plants. The higher number of flower stalks and vigorous plant growth are associated with increased seed yield of onion. The results are in line with the findings of (Aminpour & Mortazavibak, 2004; Ashagrie et al., 2014, 2021; Morozowska & Hołubowicz, 2009; Rafieipour et al., 2011).

Weight of 100 seeds

The weight of 100 seeds was not significantly influenced by individual factors (Table 3). The interaction of mother bulb surface cutting and planting date recorded significant influence on weight of 100 seed (Table 3). The highest 100 seed weight (0.48 g) was recorded under the combination of whole mother bulb and late planting date (5th April) and the lowest (0.39 g) was recorded under the combination of whole mother bulb and early planting date (20th March) (Fig. 9).

The plants produced under late planting (5th April) were relatively less vigorous and produced less yield as compared to those produced in early planting date (20th March). The less seed per plant might have insured the availability of sufficient nutrient resources for seed enlargement which could be the possible cause for higher weight of 100 seed. The authors (Khokhar, 2014; Tesfaye et al., 2018) recorded similar results.

Seed germination

None of the studied factors and their interactions had significant influence on seed germination (Table 3).

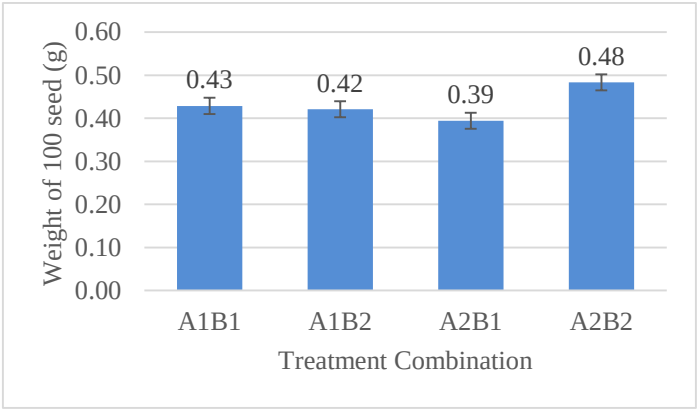

Fig. 9. The 100 seed weight of onion as affected by interaction among mother bulb surface cutting (A1: Cut bulbs, A2: Whole bulbs) and date of planting (B1: Planted on 20th March, B2: Planted on 5th April)

Table 3. The influence of onion mother bulb surface cutting, weight and planting date on number of flower stalks per plant, length of flower stalks (cm), seed yield (Kg ha^{-1}), 100 seed weight (g) and germination (%)

Treatment	Number of flower stalks per plant	Length of flower stalk (cm)	Seed yield (Kg ha^{-1})	100 Seed weight (g)	Germination (%)
Bulb surface cutting (A):					
Cut	3.35±0.16	82.90±1.92	712.22±23.73	0.43±0.02	94.22±0.99
whole	3.44±0.16	83.74±1.42	838.33±42.19	0.44±0.02	93.67±0.87
Planting date (B):					
20th March	3.32±0.17	85.30±1.33	810.00±42.86	0.41±0.02	93.44±0.98
5th April	3.48±0.14	81.35±1.87	740.55±28.85	0.45±0.02	94.44±0.87
Bulb weight (C):					
26-75 g	2.95±0.16b	84.95±1.65	699.17±29.94b	0.43±0.02	95.17±0.97
76-125 g	3.56±0.19a	83.92±1.56	805.83±46.90a	0.43±0.03	93.83±1.19
126-175 g	3.70±0.16a	81.11±2.72	820.83±51.19a	0.44±0.03	92.83±1.19
Bulb surface cutting (A):					
F-test	NS	NS	NS	NS	NS
Planting date (B):					
F-test	NS	NS	NS	NS	NS
Bulb weight (C):					
F-test	**	NS	*	NS	NS
$LSD_{0.05}$	0.44		94.29		
CV (%)	14.90		14.10		
Interaction:					
A×B	NS	NS	NS	*	NS
A×C	NS	NS	*	NS	NS
B×C	*	NS	*	NS	NS
A×B×C	*	NS	NS	NS	NS

* and NS stands for significant and non-significant, respectively. Values in the same column for each factor followed by the same letter are not significantly different, according to LSD at 0.05 level. ± SE.

CONCLUSION

The findings of this investigation reveal that, surface cutting of mother bulbs alone do not influences plant growth and seed yield. However, the interaction of large bulb and bulb surface cutting was significant on seed yield. The large sized whole bulbs produced higher seed yield as compared to other treatments. The early planting increased plant growth and seed yield. The large bulbs (126-175 g) produced vigorous plants and higher yield. However, the seed yield produced from medium bulbs (76-125 g) was on par with large bulbs. Based on the findings of the study, the farmers are recommended to avoid the surface cutting of mother bulbs. They are also recommended to follow early planting of medium sized bulbs (76-125 g) for vigorous plants and higher seed yield of onion.

Conflict of interest

The authors declare that they have no conflict of interest.

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